



King's Research Portal

DOI:

[10.1097/ID.0000000000000472](https://doi.org/10.1097/ID.0000000000000472)

Document Version

Peer reviewed version

[Link to publication record in King's Research Portal](#)

Citation for published version (APA):

Yilmaz, Z. T., Ucer, C., Scher, E., Suzuki, J., & Renton, T. F. (2016). A Survey of the Opinion and Experience of UK Dentists: Part 1: The Incidence and Cause of Iatrogenic Trigeminal Nerve Injuries Related to Dental Implant Surgery. *IMPLANT DENTISTRY*, 25(5), 1-8. <https://doi.org/10.1097/ID.0000000000000472>

Citing this paper

Please note that where the full-text provided on King's Research Portal is the Author Accepted Manuscript or Post-Print version this may differ from the final Published version. If citing, it is advised that you check and use the publisher's definitive version for pagination, volume/issue, and date of publication details. And where the final published version is provided on the Research Portal, if citing you are again advised to check the publisher's website for any subsequent corrections.

General rights

Copyright and moral rights for the publications made accessible in the Research Portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognize and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the Research Portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the Research Portal

Take down policy

If you believe that this document breaches copyright please contact librarypure@kcl.ac.uk providing details, and we will remove access to the work immediately and investigate your claim.

A survey of the opinion and experience of UK dentists: Part 1: The incidence and cause of iatrogenic Trigeminal nerve injuries related to dental implant surgery

AUTHORS: Zehra Yilmaz BSc (Hons), MSc, PhD*, Cemal Ucer BDS, MSc, PhD**, Edwin Scher BDS#, Jon Suzuki DDS, PhD, MBA##, Tara Renton BDS, MDS, PhD***

ABSTRACT (232 words)

Background: Dental implant-related iatrogenic Trigeminal nerve (TG) injuries are proportionally increasing with dental implant surgery. This study, which is presented in greater detail over a series of papers, assessed the experience of implant-related TG nerve injuries among UK dentists. Incidence and cause of inferior alveolar nerve (IAN), Mental nerve (MN) and lingual nerve (LN) injuries, together with preoperative assessment and the consent process are presented in this paper.

Methods: A survey was distributed among 405 dentists attending an Association of Dental Implantology (ADI) congress in the UK, of which 187 completed the survey.

Results: Most responding dentists were full-time general practitioners. Implant dentistry training was predominately through industry-organized courses. Eighty dentists encountered implant-related IAN injuries, whilst eight encountered LN injuries. Inaccurate radiological identification of the IAN/MN and their anatomical variations (48%) were seen to be the most frequent cause of TG injuries. Disclosure of the relative risk and benefits of alternative implant treatment strategies as part of the informed consent process was not deemed to be essential by 47 (25%) of the participants.

Conclusion: Inadequate radiological assessment was the most common cause of TG nerve injury. The use of small *field of view* CBCT is therefore recommended when placing implants in the posterior mandible. Implant surgeons should acquire evidence-based skills in the prevention, diagnosis, and management of TG nerve injury as well as specific training on justification and interpretation of CBCT scans.

KEYWORDS: Incidence and cause of inferior alveolar nerve injury; Mental nerve injury; Lingual nerve injury; Dental implants; Consent procedures.

* Post-doctoral Research Assistant, Oral Surgery Dept., King's College London, UK,

** Professor in Oral Implantology, Faculty of Health and Social Care, Edge Hill University, UK

*** Professor in Oral Surgery, Oral Surgery Dept., King's College London, UK

Professor in Oral Implantology, Dept. of Periodontology and Implantology, Temple University, USA

Associate Dean for Graduate Studies, Dept. of Periodontology and Implantology, Temple University, USA

Reprint requests and correspondence to: Zehra Yilmaz, BSc (Hons), MSc, PhD, King's College London Dental Institute, Bessemer Road, London SE5 9RS

Tel: 020 3299 1219

Fax: 020 3299 1210

Email: Zehra.yilmaz@kcl.ac.uk

Trigeminal nerve (TG) injury is a common cause for complaints by patients left with lifelong oro-facial neuropathy following dental treatment.^[1-3] TG injuries are characterized by neurosensory disturbances, such as pain, numbness or altered tingling-type sensations (paraesthesia), within the teeth, skin and the mucosa.^[4-7] The inferior alveolar nerve (IAN) and mental nerve (MN) and the lingual nerve (LN) are the most commonly damaged nerves during dental implant treatment^[6, 8-12] with some studies reporting an incidence rate of up to 40% of nerve damage following implant placement surgery in the mandible related to the depth and the width of the implant bed preparation.^[8, 11, 13-20]

Local anesthetic injections also cause TG damage due to mechanical or chemical injury.^[8, 20, 24-27] Hemorrhage within the inferior dental canal (IDC) can cause chemical nerve injury (related to the iron content in the hemoglobin directly irritating the nerve tissue), or damage due to direct mechanical pressure and indirect ischaemia.^[25, 27-29] TG injury may also be caused by bone graft harvesting,^[30] third molar surgery, endodontics, ablative surgery, trauma, thermal stimuli and ischaemia, and orthognathic surgery, or a combination of these etiologies.^[3, 4, 8, 11, 27, 31-37]

Iatrogenic TG injuries may result in a neurological deficit ranging from total loss of sensation (anesthesia) to a mild decrease in feeling (mild hypoesthesia), troublesome altered sensation (dysesthesia).^[4, 21, 38-41] whereby up to 70% of the affected patients can have pain.^[4] These symptoms may be constant, spontaneous or evoked (allodynia is a pain response to a normal stimulus), and interfere significantly with everyday functions such as speech, eating, kissing, amongst many others.^[4] Thus, these injuries have a significant negative effect on the patient's self-image, quality of life and significant psychological effects that may include suicidal thoughts due to their pain.^[20, 42, 43] The consequences of implant therapy can be devastating for these patients as the treatment results of IAN injuries are also often disappointing.^[44]

Adjunctive procedures are also sometimes attempted to avoid implant nerve injury.^[45] However, previous studies have indicated that regardless of the surgeon's experience, these high-risk procedures that include bone graft harvesting, posterior alveolar distraction and nerve lateralization, may be more likely to result in

injury themselves.^[11, 23, 30, 46-48] The most significant issue with dental implant nerve injuries is that higher standards of planning and care would minimize the chances of nerve injuries from occurring.^[49, 50]

A recent study showed an alarming lack of written consent for relatively high-risk elective surgery of implant placement in the mandible.^[49] However, an informed consent process based on adequate assessment, diagnosis and treatment planning is crucial particularly in high risk cases.^[49, 51-54] The Association of Dental Implantology (ADI) of the United Kingdom (UK), Faculty of General Dental Practitioners (FGDP, UK) as well as other international associations such as the Academy of Osseointegration (AO), International Congress of Oral Implantologists (ICOI), the International Team for Implantology (ITI) and the American Academy of Implant Dentistry (AAID) all regularly publish guidelines^[12, 52, 56-58] on implant surgery and minimum requirements for diagnostic elements. It is not clear, however, as to whether every clinician who practices the placement of implants follows these guidelines. Studies into whether patients are consented appropriately with respect to iatrogenic nerve injury related to implant dentistry also need to be carried out.

AIMS AND OBJECTIVES:

This study aimed to specifically explore the opinion and clinical experiences of a cohort of experienced implant dentists on the incidence and cause of TG injury related to implant surgery in the UK.

METHODS:

A questionnaire was designed in accordance with the aims of the study, using online software hosted by Survey Monkey[®] (surveymonkey.com, London).^[59] The questionnaire consisted of 41 questions, which were adapted from a previous study.^[25] The questionnaire was piloted to improve the accuracy and clarity of the questions. The dentists who took part in the pilot study did not complete the final version of the survey.

Subjects

All dentists (n=405) attending ADI's national congress on dental implantology were invited to complete the survey. Reminders were issued throughout the congress held between 1-3rd May 2013 to encourage maximum participation. To reduce sampling bias, non-attending members of ADI were also invited to

participate through electronic postings. Finally, members of the British Association of Oral Surgeons (BAOS) were invited to complete the online questionnaire. Within the framework of this survey, a dentist was defined as experienced in implant dentistry if they had any postgraduate training in implant dentistry (e.g. Postgraduate (PG) Diploma), and had placed more than 100 implants in total. Only dentists who placed implants in the posterior mandible (irrespective of their experience level) were admitted to the study. The study closed on 30th May 2013.

Data analyses

Responses were collected using the SurveyMonkey[®] (surveymonkey.com) software. The system was set to disallow multiple responses per email address, but to allow the participants to re-enter the survey and update their responses at a later date. Data were exported into Excel (Microsoft Version 2011) and/or the “Statistical Package for Social Sciences” (SPSS Version 22; Inc, Chicago, IL, USA) format and analyzed using descriptive and frequency analysis statistics.

RESULTS

General demographics of the responders

187 of 405 dentists (46.2%) responded to the survey. The most frequent age group of the respondents was 40-49 years (n=61), followed by 50-59 years (n=53) and 30-39 years (n=46). 17 were between 60-69 and three were between 70-80 years of age. Most respondents were in full-time *general practice* followed by those in *specialist practice* and *practice limited to implantology*. Oral and Maxillofacial Surgery (the specialty of Oral Surgery (OS) in the UK requires a single dental degree, whereas the separate medical specialty of Oral and Maxillofacial surgery (OMFS), requires both dental and medical degrees) represented the largest group of specialists (n=33 OS and n=4 OMFS). Other specialties included: prosthodontics (n=10), periodontology (n=11), restorative dentistry (n=4), endodontics (n=3).

- Postgraduate training of the participants in implant dentistry:

Whilst the training was dominated by industry-organized courses (42%), 40 (24%) of the 164 respondents had specialty training in an allied discipline (e.g. prosthodontics, periodontology or oral surgery), 43 (26%)

had completed an accredited certificate course, and 77 (47%) had a Postgraduate (PG) Diploma or MSc in implant dentistry.

- The surgical implant experience of the participants:

Total implant experience estimated by the respondents ranged between 164,350 to 288,000 implants, with 62 responders placing up to 50 implants in total annually (Fig. 1). Experience of implant placement within the mandible indicated that 19 placed less than 10 implants per annum on average, followed by 46 who placed up to 25 implants per annum. Between 25-200 mandibular implants were placed by 99 (58%) responders. Seven practitioners reportedly placed between 201-300 mandibular implants. Only one practitioner reported placing more than 500 mandibular implants.

Consent process for implant placement in the posterior mandible

- Determination of treatment needs index and/or complexity of treatment:

59 of the 144 responders (41%) used *SAC classification (ADI Guidelines on Implantology, 2012)*^[56] whilst 60 (42%) said they followed *FGDP Guidelines on Training Standards in implant dentistry*^[60] to determine if the complexity of a given case fell within their level of clinical competence or experience. Cologne ABC risk assessment scores^[55] was used only by three responders. Forty-three (30%) responders did not carry out any risk or complexity assessment before obtaining consent for surgery.

- Consent process:

100 responders used an individualized, case-specific, consent letter, whereas 55 relied on a pro-forma consent form that included a general warning about common complications. 75% of the 187 participants thought it to be essential to disclose the relative risk and benefits of alternative implant treatment strategies as part of the informed consent process.

- Disclosure of possible risks and complications:

A minority included warnings of specific complications only if the safety zone was <4mm (Table 1). The possible adverse effect of TG nerve damage on quality of life, interference with applying make-up, or speaking and kissing were not routinely disclosed to the participants.

Use of Articaine in ID blocks:

93 reported they do not use Articaine in inferior dental blocks (IDB's), whilst 31 did use Articaine in IDB's.

Post-operative measures:

92 (72%) of 128 responders indicated they do *home checks* 6-12 hours after surgery for early identification of IANI. Other measures included closely monitoring and controlling post-op infection after operating in the posterior mandible (58%), removing the implant (38%) and referral for immediate management by an expert/specialist (37%), as soon as IANI is diagnosed. Some dentists indicated that they would decompress the nerve (19.5%) and twenty others (15.6%) would observe and monitor the nerve injury for a few weeks before deciding on any definitive surgical intervention to see if the injury would heal spontaneously.

Trigeminal nerve injuries related to implant surgery in the UK

Respondents' experience of nerve damage:

Most respondents (94% of 128 responses) stated that they did not experience any IANI's (63%) or lingual nerve injuries (LNI) following implant surgery. Forty-three (23%) participants did, however, encounter between 1-5 IANI's compared to seven (4%) who saw 1-5 LNI's associated with implant treatment. No dentists saw more than six LNI's related to implant placement but very small numbers of dentists did encounter between 6-10 or 11-20 implant-related IANI's (n=3 and n=2, respectively). Many of these injuries were of immediate onset (54%). 28% of IANI's and 79% of LNI's were permanent.

Causes of implant-related trigeminal nerve injuries:

Inaccurate radiological identification of the inferior alveolar nerve/mental nerve and their anatomical variations (48%; Fig. 2) were seen to be the most frequent cause of IANI according to 54 responders.

- LA-related IANI:

132 responders did not encounter any LA-related IANI. Respondents' experience of the main predictors of nerve damage related to LA during dental implant surgery is summarized in (Fig. 3). The LA infiltration-only technique was used by 70 responders for implant placement surgery in the posterior mandible, and 49 used it only in selected cases. Articaine was the most frequently cited LA used for infiltration in the posterior mandible, at 69 responders, followed by Lignocaine (46 responders). Although the infiltration-only technique was stated to be always effective by 84 responders, 22 stated that the technique sometimes failed to achieve adequate anesthesia and 9 reported that it was not always very effective.

Symptoms experienced by the IANI patients reported by the respondents are shown in (Fig. 4).

DISCUSSION

The response rate in this survey was average, at 46.2%. This may be due to relatively low number of implants being placed by a relatively small number of dentists in the UK. Most responders were general dental practitioners who were rated to be “experienced”, and had received structured implant training.

Incidence of TG injuries

The incidence of dental implant related nerve sensory damage (NSD) has been shown to be as high as 40% in past studies^[8, 11, 13-20] although at least one prospective large cohort study has shown that risk of TG injuries can be eliminated with meticulous attention to planning and observing good surgical protocols.^[61] Nevertheless, the large variation in the reported incidence of NSD suggests that this serious complication of dental implant surgery has not yet been adequately evaluated and reported.^[62]

The results of the current study suggest a lower incidence of NSD related to dental implants than that has been reported in the literature.^[8, 11, 13-20] This may be due to majority of the responders being relatively experienced surgeons in implant dentistry. Furthermore, a high percentage of the responders appeared to have some risk management strategies in place to reduce the risk TG injuries. These include allowing a “*safety zone*” of 2-4 mm between the apex of the implant and the nerve and using *shorter implant* lengths of 10mm or less when bone height is restricted. It is also possible that the LA techniques and drugs reportedly used by the participants may have had an influence on the lower incidence of NSD. A shortcoming of this study was that the participants were not specifically questioned whether or not the location and/or number of implants might have been associated with NSD in their experience.

Symptoms experienced by the patients

The NSD reported by the participants in this study are consistent with the literature which shows that TG injury following implant placement is a serious complication that can have a profound negative effect on the well-being, psychological health and quality of life of the patient.^[4, 20, 42-44]

Cause of Injury

Inaccurate radiological identification of the IAN/MN (and their anatomical *variations*) was cited as the most frequent cause of IANI in the current study. This is supported by the literature and highlights the important role Cone Beam Computer Tomography (CBCT) could play in reducing the risk of TG damage

thus significant morbidity.^[63] In this respect it is important to note that the American Academy of Oral and Maxillofacial Radiology (AAOMR), in their revised evidence-based position statement on the selection criteria for radiology in implant dentistry, recommended that *cross-sectional imaging (CBCT) should be used for the assessment of all dental implant sites*.^[64] Another weakness of the current study was that a possible correlation between the use of CBCT and the reported incidence of nerve damage was not investigated. The role of CBCT in this respect should be made a priority of future studies.

Preoperative Risk Assessment

30% dentists admitted that they did not carry out any risk or complexity assessment before obtaining consent for an elective procedure of relatively high risk implant placement surgery in the posterior mandible, despite clear guidelines to the contrary.^[52, 55] This finding is consistent with a recent Italian study which concluded that, in just over 50% of the malpractice claims investigated, a large number of surgical errors were responsible for the high proportion of injuries to vital structures such as IAN 32.2% and LN 2.5%.^[66] The researchers have reported that in 54.5% of these cases incomplete clinical documentation and preoperative planning were evident. It is particularly striking to note that dental implant related NSD could be fully avoidable^[31] since the current evidence suggests that these injuries are commonly caused by surgical errors that are directly associated with insufficient preoperative assessment or planning.^[49] Inadequate radiological imaging and/or violation of established protocols and good practice guidelines published by ITI^[54], AO^[52], ICOI^[12], ADI^[56], and European Association of Osseointegration (EAO)^[65], appear to be responsible for these complications.^[10, 22, 31, 53, 64, 68, 69]

Consent

The current study is consistent with the literature in suggesting that risk assessment, treatment planning and the consent processes employed by implant dentist may be short of the best practice guidelines in implant dentistry. This was also shown by Strietzel (2003) who documented generally insufficient patient information, during consent, on the nature of the procedure, its financial considerations or alternatives.^[70] The clinician has the responsibility to recommend the best evidence-based treatment that is most appropriate to each individual patient's needs and disclose all possible risks (e.g. in the context of IANI; altered sensation and/or chronic neuropathic pain that may affect their daily functions and quality of life), and the alternative procedures (e.g. bone grafting vs. shorter implants) before proceeding with implant treatment.^[14, 49, 51, 71-73] As the failure to

carry out adequate examination and risk assessment and failure to conform to best practice guidelines could invalidate the consent process and lead to malpractice claims, this practice needs to be investigated in future studies and should be made a priority in training of implant dentists.

Radiological assessment of the implant site

Conventional Radiography

Panoramic radiographs are safe and reliable techniques for assessing bone height and space when there is sufficient bone above IAN to allow an adequate margin of safety for implant placement.^[61] Bartling *et al.* (1999)^[17] recommended that a safety margin wider than 2 mm should be allowed when relying only on a panoramic radiograph. Kuzmanovic *et al.* (2003)^[72] showed that 62% of the anatomically identified mental loops were not observed on panoramic radiographs. Similarly, a CBCT study^[74] found that it was not safe to use an arbitrary safety margin (of 2-4 mm) and recommended that individual assessments should be made on a *case-by-case basis*. Clearly, clinicians should pay attention to the likely location of vital anatomical structures and their possible variations when selecting and justifying the most appropriate method of diagnostic imaging in the mandible.^[75]

Cross Sectional Imaging

Although the respondents believed that *insufficient preoperative assessment and planning* was the most common contributing factor for nerve damage, they used CBCT only infrequently. This may be because a clinically significant benefit of CBCT has not yet been shown definitively and the risks may still be seen to outweigh the benefits.

Currently, there are many clinical situations in which CBCT would be highly desirable or strongly indicated for optimal preoperative implant planning and such practice could help to reduce the risk of collateral damage occurring to adjacent vital structures.^[64, 76] Moreover, CBCT data can be of further use in 3D implant navigation surgery as well as in digital workflow for the prosthetic construction. In many cases, this could change the risk/benefit analysis when selecting/justifying the diagnostic imaging method especially if the radiation is reduced further by selecting smaller *field of view* (FOV).^[77] On the other hand though, CBCT is still a highly invasive radiological technique and therefore it is recommended only as a *supplementary method* in implant planning by most dental organizations.^[12, 52, 54, 56-58, 65, 68, 78]

Nevertheless, the current results and literature support the view that CBCT should be considered as the choice of diagnostic imaging when planning implant treatment in close proximity of the vital structures particularly when there is restricted bone quality or quantity.^[64] Additional benefits of CBCT would include; the use of computer-aided design or computer-aided surgical guide manufacturing, using dynamic navigation surgical techniques,^[80] determination of the length and width of the implant to be placed,^[81-83] and identification of anatomic variations and locating nutrient canals. However, dental practitioners should prescribe CBCT imaging only when they expect that the diagnostic yield will benefit patient care, enhance patient safety or improve clinical outcomes significantly.^[64, 78, 86]

CONCLUSION

The outcome of IANI can be devastating for the effected patient. This study fortunately showed relatively low incidences of implant related IAN and LN injury. This may have been due to many of the respondents being experienced who used some risk management strategies and had formal training in implant dentistry at Postgraduate Diploma/MSc level.

Surgeons in this survey predominately believed that nerve damage was caused as a result of inaccurate radiological identification of the IAN & MN. The study also highlighted that risk assessment, treatment planning and the consent processes employed by implant dentists may be short of the best practice guidelines in implant dentistry.

In view of the findings of this study and the accumulating evidence for the use of 3D imaging in implant dentistry, the authors recommend the use of small FOV CBCT when operating in close proximity of vital structures in the mandible in order to accurately localize these structures and to select the optimum implant site and dimensions with an adequate safety margin. When doing so, established diagnostic imaging selection and justification criteria should be carefully considered with special reference to case-based risk/benefit analysis. Further studies are indicated to show a definitive clinical significance for using CBCT in reducing the risk of TG nerve injuries in implant dentistry.

ACKNOWLEDGEMENTS: We would like to thank the ADI for providing the funding that helped the progress of this project.

DISCLOSURE: The authors claim to have no financial interest, either directly or indirectly, in the products or information listed in the paper.

REFERENCES:

- [1] Caissie R, Goulet J, Fortin M, Morielli D. Iatrogenic paresthesia in the third division of the trigeminal nerve: 12 years of clinical experience. *J Can Dent Assoc.* 2005; **71**: 185-90.
- [2] Ruga E, Gallesio C, Boffano P. Mandibular alveolar neurovascular bundle injury associated with impacted third molar surgery. *J Craniofac Surg.* 2010; **21**: 1175-7.
- [3] Givol N, Rosen E, Bjorndal L, Taschieri S, Ofec R, Tsesis I. Medico-legal aspects of altered sensation following endodontic treatment: a retrospective case series. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 2011; **112**: 126-31.
- [4] Renton T, Yilmaz Z. Profiling of patients presenting with posttraumatic neuropathy of the trigeminal nerve. *J Orofac Pain.* 2011; **25**: 333-44.
- [5] Kutuk N, Gonen ZB, Yasar MT, Demirbas AE, Alkan A. Reliability of panoramic radiography in determination of neurosensory disturbances related to dental implant placement in posterior mandible. *Implant Dent.* 2014; **23**: 648-52.
- [6] Boffano P, Roccia F, Gallesio C. Lingual nerve deficit following mandibular third molar removal: review of the literature and medicolegal considerations. *Oral Surg Oral Med Oral Pathol Oral Radiol.* 2012; **113**: e10-8.
- [7] Penarrocha M, Cervello MA, Marti E, Bagan JV. Trigeminal neuropathy. *Oral Dis.* 2007; **13**: 141-50.
- [8] Tay AB, Zuniga JR. Clinical characteristics of trigeminal nerve injury referrals to a university centre. *Int J Oral Maxillofac Surg.* 2007; **36**: 922-7.
- [9] Juodzbals G, Wang HL, Sabalys G, Sidlauskas A, Galindo-Moreno P. Inferior alveolar nerve injury associated with implant surgery. *Clin Oral Implants Res.* 2013; **24**: 183-90.

- [10] Juodzbals G, Wang HL, Sabalys G. Injury of the Inferior Alveolar Nerve during Implant Placement: a Literature Review. *J Oral Maxillofac Res.* 2011; **2**: e1.
- [11] Misch CE, Resnik R. Mandibular nerve neurosensory impairment after dental implant surgery: management and protocol. *Implant Dent.* 2010; **19**: 378-86.
- [12] Misch CE, Perel ML, Wang HL et al. Implant success, survival, and failure: the International Congress of Oral Implantologists (ICOI) Pisa Consensus Conference. *Implant Dent.* 2008; **17**: 5-15.
- [13] Balshi TJ. Preventing and resolving complications with osseointegrated implants. *Dent Clin North Am.* 1989; **33**: 821-68.
- [14] Delcanho RE. Neuropathic implications of prosthodontic treatment. *J Prosthet Dent.* 1995; **73**: 146-52.
- [15] Rubenstein JE, Taylor TD. Apical nerve transection resulting from implant placement: a 10-year follow-up report. *J Prosthet Dent.* 1997; **78**: 537-41.
- [16] Wismeijer D, van Waas MA, Vermeeren JI, Kalk W. Patients' perception of sensory disturbances of the mental nerve before and after implant surgery: a prospective study of 110 patients. *Br J Oral Maxillofac Surg.* 1997; **35**: 254-9.
- [17] Bartling R, Freeman K, Kraut RA. The incidence of altered sensation of the mental nerve after mandibular implant placement. *J Oral Maxillofac Surg.* 1999; **57**: 1408-12.
- [18] Walton JN. Altered sensation associated with implants in the anterior mandible: a prospective study. *J Prosthet Dent.* 2000; **83**: 443-9.
- [19] von Arx T, Hafliger J, Chappuis V. Neurosensory disturbances following bone harvesting in the symphysis: a prospective clinical study. *Clin Oral Implants Res.* 2005; **16**: 432-9.
- [20] Hillerup S. Iatrogenic injury to oral branches of the trigeminal nerve: records of 449 cases. *Clin Oral Investig.* 2007; **11**: 133-42.
- [21] Shavit I, Juodzbals G. Inferior alveolar nerve injuries following implant placement - importance of early diagnosis and treatment: a systematic review. *J Oral Maxillofac Res.* 2014; **5**: e2.
- [22] Misch K, Wang HL. Implant surgery complications: etiology and treatment. *Implant Dent.* 2008; **17**: 159-68.

- [23] Li J, Wang HL. Common implant-related advanced bone grafting complications: classification, etiology, and management. *Implant Dent*. 2008; **17**: 389-401.
- [24] Renton T, Adey-Viscuso D, Meechan JG, Yilmaz Z. Trigeminal nerve injuries in relation to the local anaesthesia in mandibular injections. *Br Dent J*. 2010; **209**: E15.
- [25] Renton T, Janjua H, Gallagher JE, Dalglish M, Yilmaz Z. UK dentists' experience of iatrogenic trigeminal nerve injuries in relation to routine dental procedures: why, when and how often? *Br Dent J*. 2013; **214**: 633-42.
- [26] Hillerup S, Jensen R. Nerve injury caused by mandibular block analgesia. *Int J Oral Maxillofac Surg*. 2006; **35**: 437-43.
- [27] Mahon N, Stassen LF. Post-extraction inferior alveolar nerve neurosensory disturbances--a guide to their evaluation and practical management. *J Ir Dent Assoc*. 2014; **60**: 241-50.
- [28] Pogrel MA, Thamby S. Permanent nerve involvement resulting from inferior alveolar nerve blocks. *J Am Dent Assoc*. 2000; **131**: 901-7.
- [29] Crean SJ, Powis A. Neurological complications of local anaesthetics in dentistry. *Dent Update*. 1999; **26**: 344-9.
- [30] Silva FM, Cortez AL, Moreira RW, Mazzonetto R. Complications of intraoral donor site for bone grafting prior to implant placement. *Implant Dent*. 2006; **15**: 420-6.
- [31] Renton T. Prevention of iatrogenic inferior alveolar nerve injuries in relation to dental procedures. *Dent Update*. 2010; **37**: 350-2, 4-6, 8-60 passim.
- [32] Renton T, Yilmaz Z, Gaballah K. Evaluation of trigeminal nerve injuries in relation to third molar surgery in a prospective patient cohort. Recommendations for prevention. *Int J Oral Maxillofac Surg*. 2012; **41**: 1509-18.
- [33] Alves FR, Coutinho MS, Goncalves LS. Endodontic-related facial paresthesia: systematic review. *J Can Dent Assoc*. 2014; **80**: e13.
- [34] Boffano P, Roccia F, Gallesio C, Karagozoglu K, Forouzanfar T. Inferior alveolar nerve injuries associated with mandibular fractures at risk: a two-center retrospective study. *Cranio Maxillofac Trauma Reconstr*. 2014; **7**: 280-3.

- [35] Nguyen E, Grubor D, Chandu A. Risk factors for permanent injury of inferior alveolar and lingual nerves during third molar surgery. *J Oral Maxillofac Surg*. 2014; **72**: 2394-401.
- [36] Agbaje JO, Salem AS, Lambrichts I, Jacobs R, Politis C. Systematic review of the incidence of inferior alveolar nerve injury in bilateral sagittal split osteotomy and the assessment of neurosensory disturbances. *Int J Oral Maxillofac Surg*. 2015; **44**: 447-51.
- [37] Politis C, Lambrichts I, Agbaje JO. Neuropathic pain after orthognathic surgery. *Oral Surg Oral Med Oral Pathol Oral Radiol*. 2014; **117**: e102-7.
- [38] Renton T, Yilmaz Z. Managing iatrogenic trigeminal nerve injury: a case series and review of the literature. *Int J Oral Maxillofac Surg*. 2012; **41**: 629-37.
- [39] Wright EF. Persistent dysesthesia following dental implant placement: a treatment report of 2 cases. *Implant Dent*. 2011; **20**: 20-6.
- [40] Givol N, Peleg O, Yarom N, Blinder D, Lazarovici TS. Inferior alveolar neurosensory deficiency associated with placement of dental implants. *J Periodontol*. 2013; **84**: 495-501.
- [41] Al-Ouf K, Salti L. Postinsertion pain in region of mandibular dental implants: a case report. *Implant Dent*. 2011; **20**: 27-31.
- [42] Smith JG, Elias LA, Yilmaz Z et al. The psychosocial and affective burden of posttraumatic neuropathy following injuries to the trigeminal nerve. *J Orofac Pain*. 2013; **27**: 293-303.
- [43] Leung YY, Lee TC, Ho SM, Cheung LK. Trigeminal neurosensory deficit and patient reported outcome measures: the effect on life satisfaction and depression symptoms. *PLoS One*. 2013; **8**: e72891.
- [44] Bagheri SC, Meyer RA. Management of mandibular nerve injuries from dental implants. *Atlas Oral Maxillofac Surg Clin North Am*. 2011; **19**: 47-61.
- [45] Khawaja N, Renton T. Case studies on implant removal influencing the resolution of inferior alveolar nerve injury. *Br Dent J*. 2009; **206**: 365-70.
- [46] Cortes AR, Cortes DN. Nontraumatic bone expansion for immediate dental implant placement: an analysis of 21 cases. *Implant Dent*. 2010; **19**: 92-7.

- [47] Karlis V, Bae RD, Glickman RS. Mandibular fracture as a complication of inferior alveolar nerve transposition and placement of endosseous implants: a case report. *Implant Dent.* 2003; **12**: 211-6.
- [48] Gorustovich A, Guglielmotti MB. Histomorphometric study of peri-implant bone healing in the case of nerve injury: an experimental model in rats. *Implant Dent.* 2001; **10**: 203-8.
- [49] Renton T, Dawood A, Shah A, Searson L, Yilmaz Z. Post-implant neuropathy of the trigeminal nerve. A case series. *Br Dent J.* 2012; **212**: E17.
- [50] Brook I. Summary of: Post-implant neuropathy of the trigeminal nerve. A case series. *Br Dent J.* 2012; **212**: 544-5.
- [51] Gotfredsen K, Carlsson GE, Jokstad A et al. Implants and/or teeth: consensus statements and recommendations. *J Oral Rehabil.* 2008; **35 Suppl 1**: 2-8.
- [52] AO. 2010 Guidelines of the Academy of Osseointegration for the provision of dental implants and associated patient care. *Int J Oral Maxillofac Implants.* 2010; **25**: 620-7.
- [53] BDIZ EDI. Guidelines: Three Dimensional Imaging in Dental Implantology. 2009.
- [54] ITI. Proceedings of the Fifth ITI Consensus Conference. *Int J Oral Maxillofac Implants.* 2014; **29**, **Supplement**.
- [55] BDIZ EDI. Cologne ABC Risk Score for Implant Treatment: 7th European Consensus Conference of BDIZ EDI, February. 2012: 1-8.
- [56] ADI. http://www.adl.org.uk/profession/training_standards/. 2012.
- [57] AAID. <http://www.aaid.com/index.html>. 2016.
- [58] Bornstein MM, Al-Nawas B, Kuchler U, Tahmaseb A. Consensus statements and recommended clinical procedures regarding contemporary surgical and radiographic techniques in implant dentistry. *Int J Oral Maxillofac Implants.* 2014; **29 Suppl**: 78-82.
- [59] SurveyMonkey. <https://http://www.surveymonkey.com>.
- [60] FGDP U. FGDP Guidelines on Training Standards in implant dentistry 2012.
- [61] Vazquez L, Saulacic N, Belser U, Bernard JP. Efficacy of panoramic radiographs in the preoperative planning of posterior mandibular implants: a prospective clinical study of 1527 consecutively treated patients. *Clin Oral Implants Res.* 2008; **19**: 81-5.

- [62] Dannan A. Traumatic injury of the inferior alveolar nerve after dental implant surgery: A literature review. *The Internet Journal of Dental Science*. 2013; **12**.
- [63] Forni A, Sanchez-Garces MA, Gay-Escoda C. Identification of the mental neurovascular bundle: a comparative study of panoramic radiography and computer tomography. *Implant Dent*. 2012; **21**: 516-21.
- [64] Tyndall DA, Price JB, Tetradis S et al. Position statement of the American Academy of Oral and Maxillofacial Radiology on selection criteria for the use of radiology in dental implantology with emphasis on cone beam computed tomography. *Oral Surg Oral Med Oral Pathol Oral Radiol*. 2012; **113**: 817-26.
- [65] Harris D, Buser D, Dula K et al. E.A.O. guidelines fo the use of diagnostic imaging in implant dentistry. A consensus workshop organized by the European Association for Osseointegration in Trinity College Dublin. *Clin Oral Implants Res*. 2002; **13**: 566-70.
- [66] Pinchi V, Varvara G, Pradella F, Focardi M, Donati MD, Norelli G. Analysis of professional malpractice claims in implant dentistry in Italy from insurance company technical reports, 2006 to 2010. *Int J Oral Maxillofac Implants*. 2014; **29**: 1177-84.
- [67] SAC. <http://www iti.org/SAC-Assessment-Tool> 2007.
- [68] Benavides E, Rios HF, Ganz SD et al. Use of cone beam computed tomography in implant dentistry: the International Congress of Oral Implantologists consensus report. *Implant Dent*. 2012; **21**: 78-86.
- [69] Bornstein MM, Scarfe WC, Vaughn VM, Jacobs R. Cone beam computed tomography in implant dentistry: a systematic review focusing on guidelines, indications, and radiation dose risks. *Int J Oral Maxillofac Implants*. 2014; **29 Suppl**: 55-77.
- [70] Strietzel FP. Patient's informed consent prior to implant-prosthetic treatment: a retrospective analysis of expert opinions. *Int J Oral Maxillofac Implants*. 2003; **18**: 433-9.
- [71] Greenstein G, Tarnow D. The mental foramen and nerve: clinical and anatomical factors related to dental implant placement: a literature review. *J Periodontol*. 2006; **77**: 1933-43.

- [72] Kuzmanovic DV, Payne AG, Kieser JA, Dias GJ. Anterior loop of the mental nerve: a morphological and radiographic study. *Clin Oral Implants Res.* 2003; **14**: 464-71.
- [73] Main BG, Adair SR. The changing face of informed consent. *Br Dent J.* 2015; **219**: 325-7.
- [74] Parnia F, Moslehifard E, Hafezeqoran A, Mahboub F, Mojaver-Kahnamoui H. Characteristics of anatomical landmarks in the mandibular interforaminal region: a cone-beam computed tomography study. *Med Oral Patol Oral Cir Bucal.* 2012; **17**: e420-5.
- [75] Mraiwa N, Jacobs R, van Steenberghe D, Quirynen M. Clinical assessment and surgical implications of anatomic challenges in the anterior mandible. *Clin Implant Dent Relat Res.* 2003; **5**: 219-25.
- [76] BouSerhal C, Jacobs R, Quirynen M, van Steenberghe D. Imaging technique selection for the preoperative planning of oral implants: a review of the literature. *Clin Implant Dent Relat Res.* 2002; **4**: 156-72.
- [77] Dula K, Benic GI, Bornstein M et al. SADMFR Guidelines for the Use of Cone-Beam Computed Tomography/Digital Volume Tomography. *Swiss Dent J.* 2015; **125**: 945-53.
- [78] American Dental Association Council on Scientific A. The use of cone-beam computed tomography in dentistry: an advisory statement from the American Dental Association Council on Scientific Affairs. *J Am Dent Assoc.* 2012; **143**: 899-902.
- [79] Garg AK, Vicari A. Radiographic modalities for diagnosis and treatment planning in implant dentistry. *Implant Soc.* 1995; **5**: 7-11.
- [80] Zhao XZ, Xu WH, Tang ZH, Wu MJ, Zhu J, Chen S. Accuracy of computer-guided implant surgery by a CAD/CAM and laser scanning technique. *Chin J Dent Res.* 2014; **17**: 31-6.
- [81] Mello LA, Garcia RR, Leles JL, Leles CR, Silva MA. Impact of cone-beam computed tomography on implant planning and on prediction of implant size. *Braz Oral Res.* 2014; **28**: 46-53.
- [82] Du Toit J, Gluckman H, Gamil R, Renton T. Implant Injury Case Series and Review of the Literature Part 1: Inferior alveolar nerve injury. *J Oral Implantol.* 2014.
- [83] Scher EL. Risk management when operating in the posterior mandible. *Implant Dent.* 2002; **11**: 67-72.

- [84] Pancer B, Garaicoa-Pazmino C, Bashutski JD. Accessory mandibular foramen during dental implant placement: case report and review of literature. *Implant Dent.* 2014; **23**: 116-24.
- [85] Romanos GE, Papadimitriou DE, Royer K et al. The presence of the mandibular incisive canal: a panoramic radiographic examination. *Implant Dent.* 2012; **21**: 202-6.
- [86] Horner K, Islam M, Flygare L, Tsiklakis K, Whaites E. Basic principles for use of dental cone beam computed tomography: consensus guidelines of the European Academy of Dental and Maxillofacial Radiology. *Dentomaxillofac Radiol.* 2009; **38**: 187-95.

LEGENDS

Part 1:

Fig. 1: The estimated overall annual implant experience of the participants.

Fig. 2: Responses to the question: “what do you think have caused the IANI in your case(s)?” (n=54)

Fig. 3: Causes of LA-related IANI according to the respondents (n=132).

Fig. 4: Main symptoms of the IANI cases related to implant surgery, seen by the responders.

Table 1: Specific risk warnings disclosed by the participants to their patients prior to obtaining their consent.

